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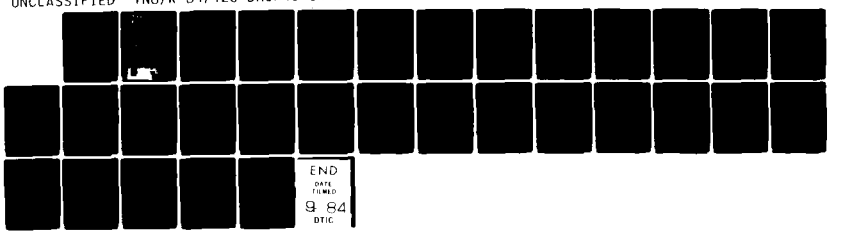

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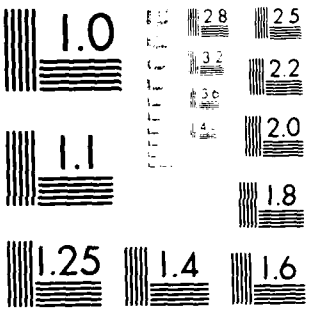

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BIOACCUMULATION OF HEAVY METALS AND ORGANIC CONTAMINANTS

Dr. J.M. Marquenie
(Principal Investigator)

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Bioaccumulation; heavy metals; organic chemicals; dredged materials; metal concentrations; PCA; PCB

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

State of the art chemical analysis techniques were used for characterizing the contamination of dredged material, animal tissue, and water samples. This report provides tabular summaries of all analytical work carried out to date, including concentrations of heavy metals and PCA and PCB in selected contaminated sediments and earthworm populations grown in the contaminated sediments.

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BIOACCUMULATION OF HEAVY METALS AND ORGANIC CONTAMINANTS

Drs J.M. Marquenie
(Principal Investigator)

TNO

p.o. box 217
2600 AE delft

address
schoemakerstraat 97

telex 38071 zptno
phone 015 - 56 93 30

Sponsor :

Department of the Army
United States Army Research,
Development and Standardization Group
223-231 Old Marylebone Road
LONDON NW1
England

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BIOACCUMULATION OF HEAVY METALS AND ORGANIC CONTAMINANTS

All analyses were carried out according to the contract no. DAJA45-84-C-0015. The complete analytical results were reported to the Waterways Experiment Station (WES) (Dr J.W. Simmers) to their full satisfation.
The draft final report is almost finished; a large portion was handed to and discussed with Dr J.W. Simmers to his agreement and will be typed in week 32.
The results already led to over five international joint WES-TNO publications.
The complete set of analytical results is added as Appendix I.

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Delft, 1984-08-01
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APPENDIX 1

Table 1 Metal concentrations ($\mu g.g^{-1}$ dry weight) in Times Beach surface disposed materials and a control (manure)

station	Cd	Cu	Hg	As
A8	2.10	116	2.10	25.0
A7	1.79	85.9	1.62	15.3
A6	0.76	60	1.52	20.0
A5	1.52	69.1	1.42	19.3
A4	1.87	94.2	1.55	24.1
A3	6.00	223	4.14	43.0
A2	2.73	148	4.22	38.5
A1 B1	7.22	238	4.50	37.7
B2	9.61	334	8.50	72.4
B3	10.8	288	5.42	53.4
B4	10.4	308	5.18	47.8
B5	2.01	88.5	1.18	12.1
B6	5.33	228	4.78	58.8
B7	6.63	224	3.94	36.4
B8	7.74	269	7.45	53.0
Man 1	0.39	16.5	< 0.74	3.40
Man 2	0.32	21.0	0.069	2.1

Table 2 Metal concentrations ($\mu g.g^{-1}$ ash-free dry weight) in experimental worms exposed to sediments described in Table 1

station	Cd	Cu	Hg	As
A8	8.86	27.7	0.482	21.1
A7	11.8	-	1.64	25.2
A6	6.54	17.3	0.981	17.5
A5	9.30	19.1	0.63	14.9
A4	13.3	20.8	0.75	17.2
A3	15.0	33.6	1.13	23.3
A2	11.7	32.1	1.39	24.0
A1 B1	9.01	44.8	0.80	32.2
B2	10.8	57.6	0.805	23.9
B3	11.4	56.2	1.22	24.6
B4	12.3	52.7	1.04	15.9
B5	7.99	28.3	1.28	10.4
B6	17.6	36.2	1.14	35.3
B7	16.0	35.2	1.13	33.0
B8	16.0	46.7	1.77	53.8
Man	3.04	10.1	0.059	8.72

Table 3 Metal concentrations ($\mu g.g^{-1}$ ash-free dry weight) in native worms at Times Beach and a reference area

area	species	Cd	Cu	Hg	As
Times Beach	Lumbricus rubellus	113.0	59.7	1.33	30.8
	" "	84.4	58.3	1.95	52.9
Reference	L. rubellus	17.6	20.2	0.469	8.84
	" "	22.4	30.2	0.549	11.8
	Allolobophora chlorotica	24.3	11.4	1.76	10.8
	" "	22.5	10.4	2.00	10.4
	Octolasium lacteum	36.5	12.5	1.77	6.47
	" "	50.7	14.8	2.34	9.59

Table 4 Metal concentrations ($\mu g.g^{-1}$ ash-free dry weight) in fishes at Times Beach and the adjacent mouth of Buffalo River

area	species	organ.	Cd	Cu	Hg	As
Times Beach	Yellow Perch	muscle	<0.013	2.44	1.16	0.214
		liver	0.042	1.32	0.102	0.936
	Pumpkin Seed	muscle	<0.019	3.30	0.717	0.579
		liver	0.316	8.00	0.355	1.89
	Rock Bass	muscle	<0.04	1.07	2.80	0.541
		liver	1.29	12.8	1.25	1.83
	Carp	muscle	<0.025	2.73	0.767	0.801
		liver	-	-	-	-
Buffalo River	Yellow Perch	muscle	<0.020	1.92	0.428	0.161
		liver	0.280	3.96	0.053	0.575
	Pumpkin Seed	muscle	<0.028	1.99	0.730	0.534
		liver	1.26	10.9	0.363	1.82

- = no data available

Table 5 PCB concentrations ($\mu g.kg^{-1}$ dry weight) in Times Beach surface disposed materials and a control (manure)

	PCB component									
station	28	52	49	70	101	87	153	138	180	HCB
A8	43	93	64	78	58	40	34	32	20	57
A7	33	110	76	120	44	27	15	20	7.7	95
A6	110	160	120	160	70	55	15	18	4	50
A5	140	180	140	220	60	39	17	37	7.1	94
A4	94	230	170	220	89	59	26	40	12	160
A3	84	290	190	230	130	89	48	79	21	320
A2	130	220	160	210	110	76	42	41	15	110
A1 B1	54	180	110	150	71	48	23	51	7.7	130
B2	55	220	150	120	140	100	71	71	34	110
B3	64	340	220	290	190	120	79	110	37	330
B4	40	170	97	210	140	72	69	99	33	290
B5	15	36	22	47	26	13	21	28	12	190
B6	50	170	110	120	110	70	46	45	22	130
B7	35	140	87	150	95	49	53	76	28	510
B8	22	93	55	42	83	50	53	52	30	79
Man 1	<10	<15	<14	<16	<17	<15	<12	<13	<16	13
Man 2	4.8	-	4.9	4.4	3.1	-	9.6	2.3	6.5	6.3

Table 6 PCB concentrations ($\mu g.kg^{-1}$ ash-free dry weight) in experimental worms exposed to disposed materials mentioned in Table 5

	PCB component									
station	28	52	49	70	101	87	153	138	180	HCB
A8	230	800	460	600	680	310	420	330	120	190
A7	160	740	510	950	420	220	180	230	64	1200
A6	530	1000	760	990	520	310	140	130	<46	350
A5	270	590	440	830	290	140	120	150	42	560
A4	200	680	480	860	360	180	130	210	43	890
A3	190	1400	910	1600	800	430	300	400	81	2000
A2	400	1000	690	830	630	360	280	230	100	510
A1 B1	240	1000	660	1200	590	340	280	360	81	890
B2	260	1700	1100	870	1100	680	470	430	150	620
B3	190	1500	970	1900	960	520	390	540	120	2100
B4	110	1000	570	1500	810	400	410	570	120	1800
B5	37	220	120	500	240	98	200	240	78	920
B6	150	870	540	430	630	360	290	250	100	560
B7	57	460	280	830	430	200	270	340	94	2500
B8	60	680	340	<45	730	350	420	350	150	460
Man	<32	<48	<45	<51	<54	<48	<39	<42	<51	19

Table 7 PCB concentrations ($\mu g.kg^{-1}$ ash-free dry weight) in native worms at Times Beach and a reference area

		PCB component									
area	species	28	52	49	70	101	87	153	138	180	HCB
T.B.	L. rubellus	126	460	220	330	320	160	130	130	50	260
		207	900	460	590	560	280	200	210	160	370
Ref.	L. rub.	all values below detection limits = < ∿ 40									13
	A. chl.	"	"	"	"	"					12
	O. lac.	"	"	"	"	"					8

Table 8 *PCB concentrations ($\mu g.kg^{-1}$ ash-free dry weight) in fishes at* Times Beach and the adjacent mouth of Buffalo River

			PCB component									
area	spec.	org.	28	52	49	70	101	87	153	138	180	HCB
T.B.	Y.P.	m	100	180	130	160	130	59	68	56	<22	38
		l	1800	3400	2500	2900	2300	840	750	580	330	580
	P.S.	m	150	290	210	290	210	110	120	100	50	46
		l	420	750	590	780	600	360	370	330	190	100
	R.B.	m	160	370	280	400	310	150	190	210	83	35
		l	200	5200	4000	5800	5200	2500	3300	3700	1500	360
	C.	m	630	1100	830	1400	570	280	260	310	110	190
		l	2100	3200	2500	4100	1800	920	800	870	220	600
B.R.	Y.P.	m	26	38	26	27	51	<23	63	50	33	4.4
		l	530	900	650	600	920	87	900	580	230	110
	P.S.	m	<18	<26	<25	<28	33	<26	47	34	<28	6.5
		l	42	70	50	64	90	<25	130	93	73	15

Table 9. PCA concentrations (ppb g^{-1} dry weight) in Times Beach surface dispersed materials and a control (manure). Approximate detection limits are indicated (d).

Station	PCA component									
	1	2	3	4	5	6	7	8	9	10
A8	3.8	1.1	3.4	2.9	0.52	d	0.58	2.8	3.0	1.8
A7	1.5	0.26	1.2	0.86	d	2.3	0.091	0.44	0.44	0.26
A6	0.54	0.18	0.59	0.53	0.068	d	0.075	0.37	0.33	0.32
A5	0.41	0.10	0.19	d	d	1.3	d	0.22	0.19	0.22
A4	0.55	0.15	0.26	d	d	2.0	d	0.24	0.21	0.36
A3	2.5	0.96	2.7	1.9	d	14	0.93	2.2	1.9	1.6
A2	2.0	0.64	2.0	2.7	0.41	d	6.1	2.5	2.2	2.1
A1 B1	4.8	1.5	5.8	4.1	d	23	0.96	3.2	2.8	1.3
B2	3.2	0.96	2.8	2.5	0.72	d	1.1	3.1	3.2	4.0
B3	2.9	0.98	2.6	2.5	d	16	0.72	2.0	2.1	2.1
B4	3.0	1.1	2.4	2.8	d	26	0.72	2.0	2.0	2.8
B5	3.5	0.64	7.5	6.1	d	8.0	0.85	4.5	4.6	2.1
B6	1.9	0.81	1.9	1.5	0.38	d	0.45	1.5	1.5	2.1
B7	2.3	1.2	3.8	3.7	d	16	0.97	3.5	3.3	2.7
B8	2.3	0.92	2.3	2.1	0.41	d	0.49	1.7	1.9	2.1
Man 1	0.43	0.021	d	d	d	d	d	d	d	d
Man 2	0.75	d	d	d	d	d	d	d	d	d
d			0.080	0.15	0.04	0.15	0.06	0.05	0.09	0.2

Table 4. PCA concentrations (µg g[1] dry weight) in [illegible] material and a control [illegible]. Approximate detection limits [illegible]

Station	PCA component										
	11	12	13	14	15	16	17	18	19	20	21
A8	d	1.1	3.0	1.7	3.8	0.67	1.3	3.4	3.0	0.81	1.1
A7	d	0.17	0.35	0.23	0.49	0.13	0.29	1.3	0.47	d	0.15
A6	d	0.15	0.43	0.25	0.56	0.14	0.43	0.29	0.47	d	0.13
A5	d	0.12	0.25	0.14	0.36	0.28	0.41	2.4	0.53	d	0.092
A4	d	0.19	0.33	0.20	0.51	0.15	0.45	1.8	0.77	d	0.16
A3	d	1.3	2.5	1.4	3.5	0.83	1.3	6.0	4.9	d	1.4
A2	d	1.2	3.5	1.9	5.2	1.4	1.7	4.5	3.1	d	1.2
A1 B1	d	1.2	3.0	1.7	4.1	0.78	1.4	5.9	4.5	d	1.2
B2	d	2.8	5.6	2.9	8.6	1.9	2.6	7.6	6.7	d	2.5
B3	d	1.5	2.6	1.5	4.1	0.98	1.4	7.5	4.9	d	1.4
B4	d	1.7	3.0	1.7	4.5	1.0	1.5	7.9	5.4	d	1.5
B5	d	1.2	4.4	2.1	4.3	0.87	0.77	5.3	3.9	d	0.96
B6	d	1.3	2.3	1.2	3.6	0.97	1.8	3.7	2.9	d	1.1
B7	d	1.6	4.0	2.2	5.3	1.1	1.7	7.8	5.6	d	1.6
B8	d	1.4	2.4	1.4	3.6	1.1	1.6	3.9	3.1	d	1.2
Man 1	d	d	d	0.032	d	d	d	0.80	d	d	d
Man 2	d	d	d	d	d	d	d	d	d	d	d
d	1.0	0.01	0.025		0.02	0.1	0.09		0.1	0.025	0.02

Table 10 PCA concentrations (ng·g^{-1} ash-free dry weight) in experimental worms exposed to Times Beach disposed materials. Approximate detection limits are indicated (d).

station	PCA component									
	1	2	3	4	5	6	7	8	9	10
A8	0.68	0.26	0.85	1.9	0.22	d	0.49	1.2	1.0	1.5
A7	0.28	0.028	0.35	0.40	0.051	3.5	d	0.22	0.24	0.24
A6	0.091	0.0076	0.099	0.14	0.018	0.074	d	0.099	0.17	0.099
A5	0.18	0.011	0.070	0.11	d	0.16	d	0.086	0.16	0.21
A4	0.20	0.011	0.071	0.14	0.032	0.23	d	0.098	0.17	0.20
A3	0.36	0.047	0.12	0.23	0.18	1.0	d	0.25	0.43	1.9
A2	0.28	0.062	0.41	0.53	0.11	1.6	0.17	0.17	0.41	0.75
A1 B1	1.4	0.37	2.4	4.5	0.13	12	0.77	1.7	1.7	3.1
B2	0.57	0.066	0.19	d	0.51	3.6	0.68	0.35	0.47	4.2
B3	0.36	0.063	0.20	0.27	0.18	2.3	0.11	0.25	0.53	2.5
B4	0.36	0.071	0.38	1.1	0.28	4.5	0.32	0.88	0.84	3.8
B5	0.25	0.010	d	d	0.045	0.72	d	0.093	0.18	0.91
B6	0.10	0.014	0.065	0.093	0.10	0.57	d	0.48	0.15	0.65
B7	0.26	0.048	0.20	0.23	0.083	0.87	d	0.25	0.35	0.81
B8	0.14	0.024	0.090	0.15	0.090	0.69	0.058	0.10	0.15	1.1
Man	0.043	0.0016	0.12	d	d	0.021	d	0.16	d	d
d				0.015	0.0040	0.015	0.050		0.0085	0.02

Table 10 PCA concentrations ($\mu g\ g^{-1}$ ash free dry weight) in experimental worms exposed to Times Beach dispersed materials. Approximate detection limits are indicated (dl) (cont'd)

Station	PCA component										
	11	12	13	14	15	16	17	18	19	20	21
A8	d	0.41	2.1	1.3	2.8	0.71	0.58	1.5	1.3	d	0.14
A7	d	0.071	0.25	0.16	0.25	0.080	0.12	0.60	0.48	d	d
A6	d	0.043	0.15	0.11	0.16	0.050	0.076	0.19	0.21	d	0.0084
A5	d	0.036	0.16	0.10	0.14	0.061	0.11	0.60	0.30	d	d
A4	d	0.055	0.22	0.12	0.25	0.11	0.15	0.50	0.44	0.013	0.011
A3	d	0.44	1.5	0.62	2.1	0.36	0.68	1.5	2.2	0.017	0.13
A2	d	0.37	1.3	0.65	1.8	0.32	0.43	1.1	1.1	d	0.11
A1 B1	d	0.93	5.2	2.7	5.8	0.60	0.97	1.8	4.4	d	0.28
B2	d	1.8	5.4	2.6	7.4	0.73	1.4	3.2	5.0	d	0.60
B3	d	0.61	2.3	1.0	2.9	0.42	0.79	1.7	3.1	d	0.13
B4	d	0.92	4.8	2.4	5.6	0.61	1.0	3.5	4.7	d	0.27
B5	d	0.27	0.64	0.30	0.75	0.24	0.36	0.89	1.3	d	0.032
B6	d	0.18	0.54	0.24	0.93	0.24	0.37	0.93	1.6	d	0.057
B7	d	0.30	0.83	0.38	1.1	0.36	0.44	1.1	1.3	d	0.11
B8	d	0.26	0.67	0.37	1.3	0.32	0.45	1.5	0.83	d	0.090
Man	d	d	d	0.0047	d	d	d	0.160	0.029	d	d
d	0.1	0.0008	0.002		0.002	0.01	0.009			0.003	0.0025

Table 11 PCA concentrations ($\mu g.g^{-1}$ ash-free dry weight) in native worms at Times Beach and a reference area. Approximate detection limits are indicated (d).

area	species	PCA component									
		1	2	3	4	5	6	7	8	9	10
T.B.	L. rubellus	0.36	0.13	0.62	0.37	0.013	0.94	0.13	0.53	0.48	0.32
		0.20	0.059	0.24	0.17	0.014	0.56	0.038	0.22	0.23	0.23
Ref.	L. rubellus	0.11	0.0048	0.051	d	d	d	d	0.012	0.020	d
		0.17	0.0090	0.086	d	d	d	d	0.022	0.040	d
	A. chlorotica	0.20	0.0064	0.090	d	0.0071	0.045	d	0.012	d	d
		0.13	0.0042	0.066	d	d	0.023	d	0.0070	0.014	d
	O. lacteum	0.088	0.0040	0.039	d	0.0040	0.013	d	0.0074	d	d
		0.11	0.0051	0.057	d	d	0.020	d	0.0072	0.027	d
d					0.002	0.0055	0.02	0.01		0.01	0.0035

Table 11 PCA concentrations ($\mu g.g^{-1}$ ash-free dry weight) in native worms at Times Beach and a reference area. Approximate detection limits are indicated (d) (cont'd).

area	species	PCA component										
		11	12	13	14	15	16	17	18	19	20	21
T.B.	L. rubellus	d	0.19	0.45	0.27	0.59	0.16	0.15	0.76	0.48	d	0.14
		d	0.13	0.27	0.14	0.31	0.086	0.13	0.64	0.30	d	0.086
Ref.	L. rubellus	d	0.0048	0.024	0.010	0.011	d	d	0.10	d	d	d
		d	0.0027	0.034	0.015	0.018	d	d	0.14	d	d	d
	A. chlorotica	d	d	0.0083	0.0051	d	d	d	0.17	d	d	d
		d	d	0.0085	0.0049	0.0028	d	d	0.18	d	d	d
	O. lacteum	d	d	0.0074	0.0047	d	d	d	0.14	d	d	d
		d	0.0015	0.019	0.0080	0.0065	d	d	0.13	d	d	d
d		0.15	0.0015			0.003	0.015	0.015		0.015	0.004	0.003

Table 12. PCA concentrations (pg g^{-1} ash-free dry weight) in fishes at Times Beach and the adjacent mouth of Buffalo River. Approximate detection limits are indicated (d).

area	species	organ	PCA component									
			1	2	3	4	5	6	7	8	9	10
T.B.	Y.P.	muscle	0.071	0.021	0.024	d	0.0051	0.056	d	d	d	d
		liver	0.77	0.26	0.25	0.19	0.042	0.58	d	0.015	d	d
	P.S.	muscle	0.11	0.044	0.065	0.025	d	0.16	d	d	d	d
		liver	0.53	0.16	0.33	0.11	0.017	0.95	d	d	d	d
	R.B.	muscle	0.12	0.018	0.031	d	d	d	d	d	d	d
		liver	0.45	0.17	0.20	0.08	d	d	d	d	d	d
	C.	muscle	0.39	0.095	0.095	0.16	d	d	d	d	d	d
		liver	0.63	0.20	0.16	0.20	d	d	d	d	d	d
B.R.	Y.P.	muscle	0.036	0.0025	0.0066	d	d	d	d	d	d	d
		liver	0.11	0.022	0.045	0.069	0.013	0.026	d	d	d	d
	P.S.	muscle	0.031	0.0022	0.0012	d	d	d		d	d	d
		liver	0.059	0.0070	0.037	0.051	0.0070	d	d	d	d	d
d		muscle				0.02	0.003	0.01	0.008	0.007	0.01	0.03
d		liver						0.02	0.02	0.01	0.03	0.08

Table 12 PCA concentrations ($pg\ g^{-1}$ ash-free dry weight) in fishes at Times Beach and the adjacent mouth of *Buffalo River*. Approximate detection limits are indicated (d) (cont'd).

area	species	organ	PCA component										
			11	12	13	14	15	16	17	18	19	20	21
T.B.	Y.P.	muscle	d	d	d	0.0041	d	d	d	0.15	d	d	d
		liver	d	0.070	d	0.011	d	d	d	0.55	d	d	d
	P.S.	muscle	d	d	d	0.0027	d	d	d	0.13	d	d	d
		liver	d	d	0.0095	0.014	d	d	d	0.63	0.13	d	d
	R.B.	muscle	d	d	d	0.0055	d	d	d	d	d	d	d
		liver	d	d	d	0.0067	d	d	d	d	d	d	d
	C.	muscle	d	0.012	0.036	d	d	d	d	d	d	d	d
		liver	d	d	d	0.0059	d	d	d	d	d	d	d
B.R.	Y.P.	muscle	d	d	d	0.0030	d	d	d	0.14	d	d	d
		liver	d	0.0075	d	0.0015	d	d	d	0.047	0.0084	d	d
	P.S.	muscle	d	d	d	0.0033	d	d	d	0.15	d	d	d
		liver	d	d	d	0.0048	d	d	d	0.22	d	d	d
d		muscle	0.1	0.0015	0.003		0.0025	0.01	0.01		0.01	0.0035	0.003
d		liver	0.35	0.0035	0.0009		0.007	0.040	0.03		0.0015	0.0095	0.008

Table 13 Metal concentrations ($\mu g.g^{-1}$ ash-free dry weight) in experimental worms exposed at the Bridgeport FVP site under field conditions and in native worms collected at transect A

	station	Cd	Cu	Hg	As
experimental	A4	9.83	73.5	1.79	14.4
	C2	6.51	36.9	0.524	34.6
	D2	9.97	32.7	1.10	13.8
native	L. rubellus	35.4	69.9	0.818	8.14
		39.9	55.7	0.708	6.69

Table 14 Metal concentrations ($\mu g.g^{-1}$ ash-free dry weight) in *Modiolus demissus* collected at the Bridgeport FVP site and the adjacent canal

area	Cd	Cu	Hg	As
FVP site	20.3	28.2	0.092	9.63
	19.3	27.0	0.103	9.78
Canal	29.0	37.1	0.152	11.7

Table 15 Metal concentrations in sediments ($\mu g.g^{-1}$ dry weight), and organisms ($\mu g.g^{-1}$ ash-free dry weight) exposed for 32 days in a tidal flow through system

		Cd	Cu	Hg	As
sediment					
sand	(S)	0.21	0.19	0.14	0.16
FVP site	(F)	0.73	43	0.24	2.8
Black Rock Control	(C)	3.6	380	0.81	8.4
Black Rock	(BR)	22	2590	3.5	12
Nereis virens	S	0.841	16.5	0.420	21.3
	F	0.874	36.0	0.335	23.7
	C	0.822	20.4	0.363	22.5
	BR	1.02	16.7	0.206	18.8
Nassarius obsoletus	S	8.59	2913	0.255	13.7
	F	11.2	3762	0.219	18.1
	C	13.4	4823	0.240	19.9
	BR	18.2	5920	0.264	24.6

Table 16 PCB concentrations ($\mu g.kg^{-1}$ ash-free dry weight) in experimental worms exposed at the Bridgeport FVP site under field conditions and in native worms collected at transect A. Approximate detection limits (d) are indicated.

		PCB component								
	station	28	52	49	70	101	87	153	138	180
experimental	A4	d	d	d	d	47	d	100	90	59
	C2	d	d	d	d	d	d	d	d	d
	C5	d	d	d	d	d	d	70	88	76
	D2	d	63	54	d	130	d	180	160	180
native	*L. rubellus*	d	55	d	d	68	d	56	67	d
		d	80	d	d	83	41	69	89	d
	d	40	60	40	50	70	50	50	60	40

Table 17 PCB concentrations ($\mu g.kg^{-1}$ ash-free dry weight) in M. demissus collected at the Bridgeport FVP site and the adjacent canal. Approximate detection limits (d) are indicated.

	PCB component								
area	28	52	49	70	101	87	153	138	180
FVP site	77	120	90	110	130	45	120	74	d
	74	120	90	110	130	45	130	75	d
Canal	107	140	110	140	140	56	120	83	d
d									35

Table 18 PCB concentrations in sediments ($\mu g.kg^{-1}$ dry weight) and organisms ($\mu g.kg^{-1}$) exposed for 32 days in a tidal flow through system. Approximate detection limits (d) are indicated.

	PCB component								
	28	52	49	70	101	87	153	138	180
sediment									
S	d	d	d	d	d	d	d	d	d
F	d	d	d	d	d	d	d	d	d
C	25	27	21	36	43	26	38	37	14
BR	250	340	230	390	430	270	300	310	110
N. virens									
S	d	d	d	d	d	d	79	44	39
F	d	d	d	d	63	d	107	83	44
C	59	101	46	d	140	d	180	140	54
BR	280	620	283	d	770	120	640	620	170
N. obsoletus									
S									
F	not yet available								
C									
BR									
d sediment	2	3	3	3	3	3	2.5	2.5	3
d organisms	25	40	35	45	45	40			

Table 19 PCA concentrations ($\mu g.g^{-1}$ ash-free dry weight) in experimental worms exposed at the Bridgeport FVP site under field conditions and in native worms collected at transect A. Approximate detection limits are indicated (d).

		PCA component									
station		1	2	3	4	5	6	7	8	9	10
experimental	A4	0.11	0.0071	0.040	0.057	d	d	d	0.031	0.058	d
	C2	0.20	0.016	0.12	0.12	0.0094	d	0.076	0.10	0.24	0.094
	D2	0.11	0.033	0.029	0.034	d	d	d	0.021	0.037	d
native	L. rubellus	0.22	0.032	0.23	0.16	d	0.034	0.013	0.11	0.12	0.059
		0.10	0.011	0.10	0.079	d	d	d	0.063	0.095	d
1						0.005	0.02	0.009			0.03

Table 19 PCA concentrations ($\mu g.g^{-1}$ ash-free dry weight) in experimental worms exposed at the Bridgeport FVP site under field conditions and in native worms collected at transect A. Approximate detection limits are indicated (d) (cont'd).

		PCA component										
station		11	12	13	14	15	16	17	18	19	20	21
experimental	A4	d	0.0035	0.022	0.015	0.014	d	0.013	0.19	d	d	d
	C2	d	0.023	0.073	0.060	0.076	0.031	0.027	0.21	0.13	d	d
	D2	d	0.0017	0.015	0.012	0.0077	d	d	0.17	d	d	d
native	L. rubellus	d	0.018	0.083	0.048	0.080	0.026	d	0.19	0.076	d	0.0097
		d	0.0095	0.060	0.032	0.033	d	d	0.042	d	d	d
1		0.2					0.015	0.02		0.02	0.006	0.005

Table 20 PCA concentrations ($\mu g.g^{-1}$ ash-free dry weight) in M. demissus collected at the Bridgeport FVP site and the adjacent canal. Approximate detection limits are indicated (d).

area	PCA component									
	1	2	3	4	5	6	7	8	9	10
FVP site	0.61	0.019	0.49	0.43	0.16	0.24	0.046	0.20	0.21	0.090
	0.50	0.014	0.36	0.33	0.12	0.18	0.045	0.16	0.13	0.079
Canal	0.47	0.025	0.96	1.3	0.73	0.80	0.21	1.2	0.79	0.66
d										

Table 20 PCA concentrations ($\mu g.g^{-1}$ ash-free dry weight) in M. demissus collected at the Bridgeport FVP site and the adjacent canal. Approximate detection limits are indicated (d) (cont'd).

area	PCA component										
	11	12	13	14	15	16	17	18	19	20	21
FVP site	d	0.0082	0.075	0.029	0.015	d	d	d	d	d	d
	d	0.0079	0.071	0.026	0.011	0.016	d	d	d	d	d
Canal	d	0.033	0.53	0.23	0.10	0.042	0.057	0.20	0.065	d	d
d	0.1					0.01	0.01	0.02	0.01	0.003	0.002

Table 21 PCA concentrations in sediments ($\mu g.g^{-1}$ dry weight) and organisms ($\mu g.g^{-1}$ ash-free dry weight) exposed for 32 days in a tidal flow through system. Approximate detection limits are indicated (d).

area	PCA component									
	1	2	3	4	5	6	7	8	9	10
sediment										
S	0.050	0.0025	d	d	d	d	d	d	d	d
F	0.10	0.0099	0.10	0.094	d	d	0.017	0.072	0.067	0.053
C	0.48	0.081	0.77	0.92	0.083	d	0.088	0.52	0.50	0.40
BR	6.9	2.3	8.1	9.2	1.2	d	1.4	6.3	5.5	3.2
N. virens										
S	0.039	0.0018	0.0089	d	d	d	d	d	d	d
F	0.058	0.0035	0.044	0.031	d	0.024	d	0.0070	d	d
C	0.055	0.0027	0.055	0.058	d	0.030	d	0.0063	d	d
BR	0.11	0.016	0.14	0.18	0.020	0.18	0.017	0.080	0.085	d
N. obsoletus										
S	0.090	0.0075	0.034	d	d	0.033	d	0.019	d	d
F	0.15	0.018	0.35	0.24	d	0.20	d	d	0.072	d
C	0.14	0.026	0.84	d	0.030	d	0.033	0.25	0.12	d
BR	0.67	0.25	4.2	6.7	0.19	d	0.52	0.95	1.7	0.26
d sediments			0.035	0.065	0.02	0.2	0.03	0.0025	0.040	0.10
d organisms				0.015	0.0045	0.01	0.007	0.005	0.01	0.025

Table 21 PCA concentrations in sediments ($\mu g.g^{-1}$ dry weight) and organisms ($\mu g.g^{-1}$ ash-free dry weight) exposed for 32 days in a tidal flow through system. Approximate detection limits are indicated (d) (cont'd).

area	PCA component										
	11	12	13	14	15	16	17	18	19	20	21
sediment											
S	d	d	d	d	d	d	d	0.82	d	d	d
F	d	0.016	0.068	0.046	0.067	0.041	d	d	0.045	d	0.014
C	d	0.16	0.69	0.36	0.88	d	0.21	1.5	0.63	d	0.13
BR	d	1.1	4.0	2.2	4.9	1.4	1.6	5.5	4.3	d	0.92
N. virens											
S	d	d	d	0.0035	d	d	d	0.21	d	d	d
F	d	0.0017	0.010	0.0096	0.0087	d	d	0.17	d	d	d
C	d	d	0.0072	0.0098	0.0063	d	d	0.17	d	d	d
BR	d	0.0026	0.12	0.15	0.23	d	d	0.17	d	d	d
N. obsoletus											
S	d	d	d	0.0067	d	d	d	0.24	d	d	d
F	d	0.0052	0.032	0.029	0.013	d	d	0.27	d	d	d
C	d	d	d	0.13	0.077	d	d	0.34	d	d	d
BR	d	0.060	0.81	0.55	0.98	0.29	d	0.47	0.31	0.034	0.021
d sediments	0.5	0.005	0.01	0.005	0.008	0.045	0.04	0.04	0.045	0.01	0.01
d organisms	0.11	0.001	0.003		0.002	0.01	0.01		0.01	0.003	0.003

Table 22 Concentrations of PCBs and PCAs (ash-free dry weight) in experimental worms exposed at the field site Ottawa (Ill.).

PCBs ($\mu g.kg^{-1}$)		PCAs ($\mu g.g^{-1}$)	
component	concentration	component	concentration
28	<23	1	0.12
52	53	2	0.0065
49	<31	3	0.033
70	<35	4	0.11
101	89	5	0.025
87	<33	6	0.11
153	270	7	0.031
138	300	8	0.083
180	210	9	0.10
		10	0.46
		11	<0.083
		12	0.14
		13	0.18
		14	0.14
		15	0.39
		16	0.71
		17	0.77
		18	1.9
		19	<0.0083
		20	<0.0024
		21	0.10

APPENDIX NOMENCLATURE OF PCB AND PCA COMPONENTS

PCB components

28	2,4,4'	-	trichlorobiphenyl
52	2,5,2',5',	-	tetrachlorobiphenyl
49	2,4,2',5'	-	"
70	2,5,3',4'	-	"
101	2,4,5,2',5'	-	pentachlorobiphenyl
87	2,3,4,2',5'	-	"
153	2,4,5,2',4',5'	-	hexachlorobiphenyl
138	2,3,4,2',4',5'	-	"
180	2,3,4,5,2',4',5'	-	heptachlorobiphenyl

PCA components

1 phenanthrene
2 anthracene
3 fluoranthene
4 pyrene
5 3,6-dimethylphenanthrene
6 triphenylene
7 benzo(b)fluorene
8 benzo(a)anthracene
9 chrysene
10 benzo(e)pyrene
11 benzo(j)fluoranthene
12 perylene
13 benzo(b)fluoranthene
14 benzo(k)fluoranthene
15 benzo(a)pyrene
16 dibenzo(a,j)anthracene
17 dibenzo(a,i)pyrene
18 benzo(g,h,i)perylene
19 indeno(1,2,3-c,d)pyrene
20 3-methylcholanthrene
21 anthanthrene

Table 24 Time dependent accumulation of heavy metals, PCBs and PCAs in Nereidae exposed to Black Rock sediments

	PCA component ($\mu g\ g^{-1}$)																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
t=0	0.25	0.014	0.17	0.15	0.029	d	d	0.049	d	d	d	d	d	0.016	d	d	d	d	d	d	d
	0.27	0.016	0.20	0.16	0.031	d	d	0.057	d	d	d	d	d	0.016	d	d	d	d	d	d	d
t=4	2.9	0.95	4.5	5.0	0.28	0.71	0.30	0.81	0.81	d	d	0.016	0.14	0.095	0.14	d	d	d	d	d	d
t=8	4.4	1.5	7.3	8.0	0.47	1.3	0.59	1.3	1.5	d	d	0.028	0.25	0.15	0.26	d	d	d	d	d	d
t=16	2.7	0.9	7.6	8.7	0.43	1.8	0.51	1.1	1.7	d	d	0.031	0.33	0.21	0.36	d	d	d	d	d	d
t=32	0.67	0.25	4.2	6.7	0.19	d	0.52	0.95	1.7	0.26	d	0.060	0.81	0.55	0.98	0.29	d	0.47	0.31	0.034	0.021

	PCB component ($\mu g.kg^{-1}$)									
	28	52	49	70	101	87	153	138	180	HCB
t=0	60	66	47	96	59	-	60	65	24	1.6
t=4	280	+	+	300	150	57	88	110	30	9.8
t=8	490	+	+	520	230	100	120	150	37	16.4
t=16	700	+	+	760	350	150	180	230	52	18
t=32	1300	1300	+	2600	1500	460	900	1200	130	11

+ = disturbed

	Heavy metals ($\mu g.g^{-1}$)			
	Cd	Cu	Hg	As
t=0	13.5	3870	0.227	23.2
t=4	16.7	4430	0.253	22.4
t=8	16.6	4590	0.250	27.2
t=16	18.9	5740	0.296	28.1
t=32	18.2	5920	0.264	24.6


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